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Research Articles

Epidemiological Trends and Thromboembolic Risks in Bimalleolar and Trimalleolar Ankle Fractures: A Retrospective Analysis of Increasing Incidence in an Aging Population

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Objective

The incidence of bimalleolar (BMF) and trimalleolar fractures (TMF) is increasing. This study assesses the epidemiological trends of bimalleolar (BMF) and trimalleolar fractures (TMF) and subsequent complications, including venous thromboembolism events (VTE).

Methods

We conducted a retrospective analysis using the TriNetX Network, which provided data from electronic medical records of 97 healthcare organizations. Patients diagnosed with BMF from 2017 to 2023 were identified using international classification of deseases 10th edition (ICD-10) codes, including S82.841A, S82.842A, and S82.843A for displaced fractures, and S82.844A, S82.845A, and S82.846A for nondisplaced fractures. For trimalleolar fractures, the codes used were S82.851A, S82.852A, and S82.853A for displaced fractures, and S82.854A, S82.855A, and S82.856A for nondisplaced fractures. Demographic data were analyzed alongside fracture displacement and VTE complications.

Results

The study analyzed 59,315 patients with bimalleolar fractures and 45,335 with trimalleolar fractures, showing that a majority of patients were older women. Displaced fractures predominated, with 89% (52,730 cases) for BMF and 90% (40,802 cases) for TMF. The incidence of thromboembolic complications was notably high, particularly in the immediate post-fracture period. VTE, including deep vein thrombosis (DVT) and pulmonary embolism (PE), was recorded in 1,218 patients (1.1% of fractures), where 42% occurred between ages 40-64 within the first week.

Conclusion

The predominance of displaced fractures and the acute onset of VTE post-fracture underscore the need for a nuanced approach to fracture management, early rehabilitation, supervised weight bearing, partial weight-bearing monitoring and programming, and early DVT prediction, particularly in older adults. Further studies should be performed to further understand and refine current guidelines and address healthcare disparities.

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INTRODUCTION

Ankle fractures, particularly bimalleolar (BMF) and trimalleolar fractures (TMF), are common and complex injuries whose incidence has been steadily rising, especially among older adults. This trend can be attributed to an aging population and increased rates of osteoporosis, which raises susceptibility to fractures from low-energy trauma such as falls, underscoring the importance of considering demographic shifts in managing ankle injuries.[1,2]

This growing body of research highlights the necessity for healthcare providers to adapt their management strategies based on demographic trends, fracture type, and individual patient characteristics. By aligning treatment choices with patient needs, clinicians can enhance recovery and functionality, particularly for elderly patients who face unique risks.[3-5]

These considerations emphasize the importance of ongoing studies to develop evidence-based guidelines that reflect both the evolving patient population and advancements in surgical options. The purpose of this study is to better understand current demographics and the incidence of BMF and TMF.

METHODS

The data used in this study were collected on October 14, 2024, and November 8, 2024, from the TriNetX Network ('Research'), which provided access to electronic medical records, including diagnoses, procedures, medications, laboratory values, and genomic information from approximately 97 healthcare organizations. The dataset comprises millions of patients, providing a comprehensive source for analysis. This retrospective study is exempt from informed consent as it involves secondary analysis of existing de-identified data. The study does not include any direct intervention or interaction with human subjects. The data has been de-identified following the de-identification standard defined in Section §164.514(a) of the Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule. The de-identification process is certified by a qualified expert according to Section §164.514(b)(1) of the HIPAA Privacy Rule, with a formal determination last updated in December 2020.

The International Classification of Diseases, 10th Edition (ICD-10) diagnosis codes were used to identify all patients diagnosed with bimalleolar or trimalleolar fractures of the right, left, or unspecified lower leg. For bimalleolar fractures, the specific ICD-10 codes included S82.841A, S82.842A, and S82.843A for displaced fractures, and S82.844A, S82.845A, and S82.846A for nondisplaced fractures. For trimalleolar fractures, the codes used were S82.851A, S82.852A, and S82.853A for displaced fractures, and S82.854A, S82.855A, and S82.856A for nondisplaced fractures. Patients diagnosed with these codes from January 1, 2017, to December 31, 2023, were included in the analysis. Cohorts were categorized by displacement status (displaced vs. nondisplaced), and demographic data such as age, sex, ethnicity, and race were collected. Annual rates for both displaced and nondisplaced bimalleolar and trimalleolar fractures were calculated, and trends were analyzed across the 2017-2023 timeframe.

To assess the incidence of thromboembolic complications following these fractures, the subsequent occurrence of deep vein thrombosis (DVT) and pulmonary embolism (PE) was identified using specific ICD-10 codes. The DVT-related codes included I82.401, I82.402, I82.403, and I82.409 for acute embolism and thrombosis of deep veins of the lower extremities, and I82.621, I82.622, I82.623, and I82.629 for acute embolism and thrombosis of deep veins of the upper extremities. Pulmonary embolism was identified using codes I26.9 (pulmonary embolism without acute cor pulmonale) and I26.99 (other pulmonary embolism without acute cor pulmonale). The incidence of DVT and PE was recorded at specific time intervals following the fracture diagnosis: within 1 week, from 1 week to 1 month, from 1 to 3 months, from 3 to 6 months, and from 6 months to 1 year.

RESULTS

PATIENT DEMOGRAPHICS AND FRACTURE DISPLACEMENT

The study included 59,315 patients with bimalleolar fractures and 45,335 with trimalleolar fractures. Among bimalleolar fractures, 89% (29,953 females, 20,777 males) were displaced, while 11% (3,330 females, 2,123 males) were nondisplaced. For trimalleolar fractures, 90% (26,231 females, 12,307 males) were displaced, with only 10.% (2,484 females, 1,095 males) being nondisplaced **[Tables 1 and 2]**.

ETHNICITY AND RACE DISTRIBUTION

For displaced and nondisplaced bimalleolar fractures, the largest ethnic group was "Not Hispanic or Latino" at 69% and 60%, respectively. Displaced and nondisplaced trimalleolar fractures had a similar distribution at 69% and 60%, respectively, for "Not Hispanic or Latino" being the majority of the population.

In terms of racial distribution, White patients comprised the largest group in displaced and nondisplaced fractures, with 67% and 60% in bimalleolar fractures, respectively, and 70% and 59% in trimalleolar fractures, respectively.

AGE DISTRIBUTION

The mean age for displaced bimalleolar fracture patients was lower than that of trimalleolar fractures at 49 ± 20 years for bimalleolar versus 52 ± 18 years for trimalleolar. The same trend continued for nondisplaced fractures: the mean age for bimalleolar fractures was lower at 51 ± 20 years, whereas trimalleolar fractures had a mean age of 53 ± 18 years.

THROMBOEMBOLIC COMPLICATIONS

Venous Thromboembolisms (VTEs) were most frequently recorded within the first week after recording the fracture,

Table 1. Trends in bimalleolar fractures

Category	2017 Displaced (n [%])	2017 Nondisplaced (n [%])	2018 Displaced (n [%])	2018 Nondisplaced (n [%])	2019 Displaced (n [%])	2019 Nondisplaced (n [%])	2020 Displaced (n [%])	2020 Nondisplaced (n [%])	2021 Displaced (n [%])	2021 Nondisplaced (n [%])	2022 Displaced (n [%])	2022 Nondisplaced (n [%])	2023 Displaced (n [%])	2023 Nondisplaced (n [%])	2017-2023 Displaced (n [%])	2017-2023 Nondisplaced (n [%])
Total	6015 (89%)	741 (11%)	6892 (88%)	929 (12%)	7676 (92%)	654 (8%)	7177 (88%)	969 (12%)	8293 (89%)	986 (11%)	8525 (90%)	935 (10%)	8221 (89%)	993 (11%)	52799 (89%)	6516 (11%)
Sex																
Female	3348 (56%)	384 (52%)	3934 (57%)	467 (50%)	4294 (56%)	340 (52%)	4040 (56%)	483 (50%)	4772 (58%)	500 (51%)	4908 (58%)	494 (53%)	4657 (57%)	530 (53%)	29953 (57%)	3330 (51%)
Male	2487 (41%)	266 (36%)	2691 (39%)	308 (33%)	3065 (40%)	156 (24%)	2813 (39%)	317 (33%)	3209 (39%)	316 (32%)	3323 (39%)	307 (33%)	3189 (39%)	286 (29%)	20777 (39%)	2123 (33%)
Unknown	180 (3.0%)	91 (12%)	267 (3.9%)	154 (17%)	317 (4.1%)	158 (24%)	324 (4.5%)	169 (17%)	312 (3.8%)	170 (17%)	294 (3.5%)	134 (14%)	375 (4.6%)	177 (18%)	2069 (3.9%)	1063 (16%)
Ethnicity																
Not Hispanic or Latino	4015 (67%)	473 (64%)	4698 (68%)	566 (61%)	5363 (70%)	399 (61%)	5024 (70%)	612 (63%)	5840 (70%)	620 (63%)	5992 (70%)	611 (65%)	5751 (70%)	652 (66%)	36683 (69%)	4140 (64%)
Unknown	1334 (22%)	192 (26%)	1423 (21%)	281 (30%)	1454 (19%)	211 (32%)	1403 (20%)	284 (29%)	1562 (19%)	287 (29%)	1589 (19%)	233 (25%)	1568 (19%)	255 (26%)	10333 (20%)	1805 (28%)
Hispanic or Latino	666 (11%)	76 (10%)	771 (11%)	82 (8.8%)	859 (11%)	44 (6.7%)	750 (10%)	73 (7.5%)	891 (11%)	79 (8.0%)	944 (11%)	91 (9.7%)	902 (11%)	86 (8.7%)	5783 (11%)	571 (8.8%)
Race																
White	4143 (69%)	465 (63%)	4724 (69%)	554 (60%)	5210 (68%)	385 (59%)	4722 (66%)	585 (60%)	5490 (66%)	572 (58%)	5698 (67%)	561 (60%)	5399 (66%)	632 (64%)	35386 (67%)	3929 (60%)
Unknown	569 (9.5%)	143 (19%)	714 (10%)	214 (23%)	825 (11%)	179 (27%)	795 (11%)	223 (23%)	901 (11%)	240 (24%)	854 (10%)	226 (24%)	904 (11%)	232 (23%)	5562 (11%)	1508 (23%)
Black	812 (14%)	92 (12%)	905 (13%)	107 (12%)	1032 (13%)	68 (10%)	1039 (14%)	119 (12%)	1174 (14%)	138 (14%)	1190 (14%)	103 (11%)	1135 (14%)	82 (8.3%)	7287 (14%)	776 (12%)
Asian	183 (3.0%)	12 (1.6%)	187 (2.7%)	19 (2.1%)	198 (2.6%)	<10 (2.0%)	197 (2.8%)	<10 (1.0%)	227 (2.7%)	<10 (1.0%)	266 (3.1%)	<10 (1.5%)	267 (3.3%)	<10 (1.5%)	1525 (2.9%)	92 (1.4%)
Native Hawaiian or other Pacific Islander	56 (0.93%)	<10 (1.4%)	70 (1.0%)	<10 (1.1%)	71 (0.93%)	<10 (1.5%)	79 (1.1%)	<10 (1.5%)	62 (0.75%)	<10 (1.0%)	45 (0.53%)	<10 (1.1%)	48 (0.58%)	<10 (1.0%)	431 (0.82%)	<10 (0.72%)
American Indian or Alaska Native	39 (0.65%)	<10 (1.4%)	40 (0.58%)	<10 (1.1%)	47 (0.61%)	<10 (1.5%)	43 (0.60%)	<10 (1.0%)	46 (0.56%)	<10 (1.0%)	34 (0.40%)	<10 (1.1%)	44 (0.54%)	<10 (1.0%)	293 (0.56%)	<10 (0.37%)
Age Group																
0-17	387 (6.4%)	56 (7.6%)	374 (5.4%)	55 (5.9%)	381 (5.0%)	<10 (1.5%)	361 (5.0%)	59 (6.1%)	425 (5.1%)	47 (4.8%)	494 (5.8%)	71 (7.6%)	482 (5.9%)	54 (5.4%)	2904 (5.5%)	384 (5.9%)
18-39	1580 (26%)	194 (26%)	1871 (27%)	221 (24%)	2075 (27%)	145 (22%)	1916 (27%)	232 (24%)	2256 (27%)	228 (23%)	2295 (27%)	203 (22%)	2189 (27%)	238 (24%)	14182 (27%)	1563 (24%)
40-64	2432 (40%)	290 (39%)	2693 (39%)	342 (37%)	2982 (39%)	276 (42%)	2800 (39%)	363 (37%)	3072 (37%)	363 (37%)	3083 (36%)	313 (33%)	2870 (35%)	325 (33%)	19932 (38%)	2355 (36%)
65-90	1333 (22%)	174 (23%)	1648 (24%)	271 (29%)	1904 (25%)	196 (30%)	1826 (25%)	274 (28%)	2183 (26%)	300 (30%)	2281 (27%)	304 (33%)	2308 (28%)	337 (34%)	13483 (26%)	1936 (30%)

Table 2. Trends in trimalleolar fractures

Category	2017 Displaced (n [%])	2017 Nondisplaced (n [%])	2018 Displaced (n [%])	2018 Nondisplaced (n [%])	2019 Displaced (n [%])	2019 Nondisplaced (n [%])	2020 Displaced (n [%])	2020 Nondisplaced (n [%])	2021 Displaced (n [%])	2021 Nondisplaced (n [%])	2022 Displaced (n [%])	2022 Nondisplaced (n [%])	2023 Displaced (n [%])	2023 Nondisplaced (n [%])	2017-2023 Displaced (n [%])	2017-2023 Nondisplaced (n [%])
Total	4165 (91%)	432 (9.0%)	5007 (90%)	556 (10%)	5646 (95%)	654 (5%)	5747 (90%)	705 (10%)	6488 (90%)	751 (10%)	6724 (90%)	808 (10%)	6821 (90%)	820 (10%)	40,598 (90%)	4736 (10%)
Sex																
Female	2635 (63%)	295 (68%)	3591 (71%)	262 (46%)	3911 (69%)	350 (53%)	4017 (70%)	457 (64%)	4059 (63%)	482 (64%)	4237 (63%)	457 (56%)	4213 (61%)	483 (58%)	26,103 (64%)	3094 (65%)
Male	1322 (32%)	115 (27%)	1457 (29%)	147 (26%)	1766 (31%)	156 (24%)	1736 (30%)	151 (21%)	1977 (30%)	154 (21%)	1999 (30%)	202 (25%)	2020 (30%)	228 (28%)	12,237 (30%)	1095 (23%)
Unknown	180 (4.3%)	102 (24%)	266 (5.3%)	157 (28%)	289 (5.1%)	158 (24%)	306 (5.3%)	177 (25%)	316 (4.9%)	188 (25%)	320 (4.8%)	162 (20%)	383 (5.6%)	212 (26%)	2060 (5.1%)	1157 (24%)
Ethnicity																
Not Hispanic or Latino	2726 (65%)	242 (56%)	3365 (67%)	314 (55%)	3933 (70%)	399 (61%)	4021 (70%)	425 (60%)	4506 (69%)	443 (59%)	4721 (70%)	525 (65%)	4734 (69%)	496 (60%)	28,006 (69%)	2844 (60%)
Unknown	1010 (24%)	147 (34%)	1175 (23%)	218 (39%)	1185 (21%)	211 (32%)	1224 (21%)	236 (34%)	1377 (21%)	264 (35%)	1344 (20%)	221 (27%)	1394 (20%)	264 (32%)	8709 (21%)	1561 (33%)
Hispanic or Latino	429 (10%)	43 (10%)	467 (9.3%)	34 (6.0%)	528 (9.4%)	44 (6.7%)	502 (8.7%)	44 (6.3%)	605 (9.3%)	44 (5.9%)	659 (9.8%)	62 (7.7%)	693 (10%)	60 (7.3%)	3883 (9.6%)	331 (7.0%)
Race																
White	3036 (73%)	258 (60%)	4100 (81%)	344 (61%)	4190 (74%)	385 (59%)	4515 (79%)	391 (55%)	4936 (76%)	396 (53%)	5051 (75%)	502 (62%)	4905 (72%)	485 (59%)	30,000 (74%)	2811 (59%)
Unknown	413 (9.9%)	116 (27%)	556 (11%)	183 (32%)	598 (11%)	179 (27%)	626 (11%)	211 (30%)	688 (11%)	225 (30%)	714 (11%)	208 (26%)	748 (11%)	249 (30%)	4343 (11%)	1371 (29%)
Black	420 (10%)	37 (8.6%)	475 (9.5%)	44 (7.8%)	588 (10%)	68 (10%)	596 (10%)	71 (10%)	767 (12%)	69 (9.2%)	787 (12%)	56 (6.9%)	729 (11%)	64 (7.8%)	4362 (11%)	409 (8.6%)
Asian	112 (2.7%)	<10 (2.3%)	125 (2.5%)	<10 (1.8%)	151 (2.7%)	<10 (1.9%)	160 (2.8%)	<10 (1.4%)	146 (2.3%)	<10 (1.3%)	206 (3.1%)	<10 (1.9%)	180 (2.6%)	<10 (1.3%)	1080 (2.7%)	69 (1.5%)
Native Hawaiian or other Pacific Islander	47 (1.1%)	<10 (2.3%)	53 (1.1%)	<10 (1.8%)	64 (1.1%)	<10 (1.5%)	47 (0.82%)	<10 (1.4%)	48 (0.74%)	<10 (1.3%)	36 (0.54%)	<10 (1.0%)	39 (0.57%)	<10 (0.47%)	334 (0.82%)	<10 (0.47%)
American Indian or Alaska Native	24 (0.58%)	<10 (2.3%)	24 (0.48%)	<10 (1.8%)	35 (0.62%)	<10 (1.5%)	42 (0.73%)	<10 (1.4%)	31 (0.48%)	<10 (1.3%)	29 (0.43%)	<10 (1.2%)	34 (0.50%)	<10 (0.36%)	219 (0.54%)	<10 (0.36%)
Age Group																
0-17	102 (2.5%)	<10 (2.3%)	91 (1.8%)	<10 (1.8%)	124 (2.2%)	<10 (1.5%)	144 (2.5%)	<10 (1.4%)	162 (2.5%)	<10 (1.3%)	147 (2.2%)	22 (2.7%)	165 (2.4%)	<10 (1.6%)	935 (2.3%)	82 (1.7%)
18-39	1037 (25%)	108 (25%)	1192 (24%)	145 (26%)	14162 (23%)	276 (42%)	1439 (25%)	301 (43%)	1526 (24%)	299 (40%)	1579 (23%)	316 (39%)	1624 (24%)	319 (39%)	9000 (22%)	1769 (37%)
40-64	1840 (44%)	203 (47%)	2253 (45%)	272 (48%)	2414 (43%)	276 (42%)	2417 (42%)	301 (43%)	2566 (40%)	299 (40%)	2779 (41%)	323 (40%)	2658 (39%)	316 (39%)	17,017 (42%)	1990 (42%)
65-90	1025 (25%)	105 (24%)	1300 (26%)	176 (31%)	1499 (27%)	196 (30%)	1509 (26%)	257 (37%)	1877 (29%)	257 (34%)	1901 (28%)	246 (30%)	2066 (30%)	275 (34%)	11,177 (28%)	1406 (30%)

Table 3. Trends in the occurrence of Deep Vein Thrombosis and Pulmonary Embolism

Category	<1 week VTE (n [%])	1 week - 1 month VTE (n [%])	1 - 3 months VTE (n [%])	3 - 6 months VTE (n [%])	6 months - 1 year VTE (n [%])
Total	1,218 (33%)	767 (21%)	820 (22%)	459 (13%)	390 (11%)
Sex					
Female	625 (52%)	433 (57%)	483 (60%)	264 (58%)	240 (62%)
Male	462 (38%)	263 (35%)	274 (34%)	151 (33%)	112 (29%)
Unknown	116 (9.6%)	65 (8.5%)	53 (6.5%)	39 (8.6%)	35 (9.0%)
Ethnicity					
Not Hispanic or Latino	808 (67%)	538 (71%)	583 (72%)	325 (72%)	263 (68%)
Unknown	334 (28%)	176 (23%)	188 (23%)	111 (24%)	103 (27%)
Hispanic or Latino	61 (5.1%)	47 (6.2%)	39 (4.8%)	18 (4.0%)	21 (5.4%)
Race					
White	786 (65%)	518 (68%)	577 (71%)	315 (69%)	255 (65%)
Unknown	202 (17%)	113 (15%)	101 (12%)	64 (14%)	56 (14%)
Black	156 (13%)	93 (12%)	94 (12%)	63 (14%)	58 (15%)
Asian	15 (1.3%)	9 (1.2%)	9 (1.1%)	5 (1.1%)	7 (1.8%)
Native Hawaiian or other Pacific Islander	-	-	-	-	-
American Indian or Alaska Native	-	-	-	-	-
Age Group					
0-17	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
18-39	209 (17%)	151 (20%)	115 (14%)	52 (11%)	35 (9%)
40-64	504 (42%)	332 (44%)	350 (44%)	202 (44%)	162 (42%)
65-90	454 (38%)	251 (33%)	314 (40%)	176 (45%)	176 (45%)

with 1218 events occurring, representing the peak incidence. Within the first week of surgery, the highest rates of venous thromboembolism (VTE) were found in whites at 65% and females at 52%. The rates of VTEs were also the highest in patients aged 40-64 compared to patients aged 18-39 and 65-90 within the first week. Females consistently had a higher VTE rate than males from <1 week to 1 year, and over time, the VTE rate in females increased from 52% at <1 week to 62% at 6-12 months. Both Non-Hispanic or Latino and Hispanic or Latino groups showed no increase in incidence of VTE when comparing incidences from <1 week to 6-12 month post-surgery. **[Table 3]**.

DISCUSSION

This study provides valuable insights into the epidemiology of bimalleolar and trimalleolar ankle fractures, including demographic trends, the incidence of displaced fractures, and thromboembolic risks. Data analysis revealed a high frequency of displaced fractures in both BMF and TMF groups **(89%** and **90%,** respectively), indicating a predominant trend toward severe injuries that may undergo surgical intervention. Notably, fracture incidence was higher among women, including displaced and nondisplaced fractures. Additionally, higher fracture incidence was observed in older adults (mean age **51-53** years) for bimalleolar and trimalleolar fractures. The highest risk of VTEs was within the first week after recording the fracture. However, the frequency of DVTs and PEs declined over time, indicating a decreasing trend as time progressed from the initial injury.

IMPLICATIONS OF DEMOGRAPHIC VARIATIONS

The impact of demographic factors, including age, sex, and ethnicity, on fracture incidence and management provides valuable insights into targeted prevention and treatment strategies. In our study, we found that the fracture incidence was most common in older women. These findings align with those of Court-Brown and Wilson, who also observed the highest incidence of ankle fractures among older women; however, their study specifically identified women aged 75 to 84 as the group with the greatest incidence.[6] We believe that older adults, especially older women, face unique challenges due to osteoporosis and heightened fall risks, which increase their likelihood of sustaining fractures. The higher prevalence of fractures in older adults underlines the importance of fall prevention measures, such as smoking cessation, regimented exercise habits, and supplemental therapy to reduce fracture incidence in this vulnerable population.[7-10]

This study's findings on ethnic and racial distribution showed White groups had the highest incidence of reported fracture at **67% and 60%** of displaced and nondisplaced fractures on average. According to the United States Census, the population is 75% White, with 58% identifying as White alone, not Hispanic or Latino.[11] Although the higher incidence of fracture among White people could simply be due to the demographic distribution in the United States,

previous studies by Bao et al.[12] found that White individuals had a significantly higher fracture risk compared to other ethnic groups, possibly due to variations in bone mineral density across these populations.[12-14] We believe that the results in our study could be attributed to a combination of United States demographics and possible differences in bone mineral density across ethnic groups.

Additionally, a lower fracture incidence amongst minority groups could reflect a lack of access to medical care in the United States, resulting in far fewer fractures being reported. For example, Hispanic and Latino people made up **8.3% and 9.9%** of TMF and BMF, respectively, while 19.5% of the United States population identifies as Hispanic or Latino.[11] Previous literature greatly details the complex relationship between ethnicity and access to quality healthcare - specifically, Bulutao and Anderson describe how 18% of Hispanic or Latino Americans are uninsured, compared with 6.6% of White Americans.[15] Considering fracture risk and access to healthcare is of the utmost importance when discussing fracture care among diverse populations. Future research could investigate how considering these factors informs more equitable and successful healthcare practices.

DVT AND PE INCIDENCE POST-FRACTURE

Thromboembolic complications were observed at the highest frequency within the first week post-fracture. These findings are consistent with those of Gouzoulis et al. on thromboembolism following foot and ankle fractures, where, in patients with venous thromboembolism (VTE) following surgery, 27% occurred in the first week after surgery and 50% occurred in the first three weeks post-operation.[16] The declining incidence over time indicates an elevated risk shortly after fracture or surgery and highlights the importance of early preventive and predictive measures. Although the frequency of VTE decreased over time in the general population, the specific breakdown and rates of the demographic population experiencing the VTEs should be noted. The rates of VTEs were the highest in patients aged 40-64 compared to patients aged 18-39 and 65-90 within the first week of surgery, indicating that necessary precautions should be taken when operating on this population, and different comorbidities should be accounted for to prevent possible DVT/PE from forming. Also, females consistently had a higher rate of developing VTEs than males from <1 week to 1 year, and the rates of VTE formation in females both increased from <1 week to 1 year, even though the general incidences of VTEs decreased among all patients who underwent surgery. Risk factors for VTEs include post-operative weight-bearing status, immobilization, infection, age, and comorbid conditions, emphasizing the importance of identifying these factors early and tailoring care accordingly during the immediate post-injury period.[17-20]

Given the significant morbidity and mortality associated with these complications, close monitoring and patient education on thromboembolism risks are crucial in the weeks following injury for early diagnosis of a DVT and prevention of a life-threatening PE. As our study's data suggest, the elevated incidence of thromboembolic events in the week following surgery reinforces the need for vigilant risk assessment and timely intervention to improve long-term patient outcomes.[21-25]

CONCLUSION

In conclusion, this study highlights the increasing incidence of ankle fractures, particularly bimalleolar and trimalleolar fractures, in an aging population. Moreover, the high risk of thromboembolic events shortly after injury calls for vigilant monitoring and preventive strategies in this patient population, including timely partial weight-bearing monitoring and programming. By aligning treatment protocols with individual patient characteristics and evolving clinical evidence, physicians can optimize outcomes and enhance the quality of care for patients with ankle fractures.

DECLARATION OF CONFLICT OF INTEREST

The authors do not have any potential conflicts of interest in the information and production of this manuscript.

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DECLARATION OF ETHICAL APPROVAL FOR THE STUDY

Given the review nature of the manuscript and the lack of patient information, no ethical approval was required.

DECLARATION OF INFORMED CONSENT

There are no patient names, initials, hospital identification numbers, photographs, or any other form of protected health information in the submitted manuscript. Given the review nature of this manuscript, no formal informed consent process was conducted.

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